IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Inventors: Timothy Giles BEARD, et al. Art Unit: 2661

Application No.: 10/787,243

Filed: February 27, 2004

For: EXTENDED DYNAMIC RESOURCE ALLOCATION IN PACKET DATA TRANSFER

CLAIM FOR PRIORITY

Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

The benefit of the filing date of the following prior foreign application filed in the following foreign country is hereby requested for the above-identified application and the priority provided in 35 USC 119 is hereby claimed:

Great Britain Appln. No. 0314093.6, filed June 18, 2003.

In support of this claim, a certified copy of said original foreign application is filed herewith.

It is requested that the file of this application be marked to indicate that the requirements of 35 USC 119 have been fulfilled and that the Patent and Trademark Office kindly acknowledge receipt of this document.

Respectfully submitted,

James E. Ledbetter
Registration No. 28,732

Date: June 7, 2004

JEL/spp
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Statement of inventorship and of right to grant of a patent

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference
1803

2. Patent application number
(if you know it)
0314093.6
18 JUN 2003

3. Full name of the or of each applicant
MATSUSHITA ELECTRIC INDUSTRIAL CO. LTD

4. Title of the invention
EXTENDED DYNAMIC RESOURCE ALLOCATION IN PACKET DATA TRANSFER

5. State how the applicant*(s)* derived the right from the inventor*(s)* to be granted a patent
BY VIRTUE OF THE EMPLOYMENT OF THE INVENTORS BY PANASONIC MOBILE COMMUNICATIONS DEVELOPMENT OF EUROPE LIMITED (PMCDE) AND AN AGREEMENT BETWEEN PMCDE AND THE APPLICANT

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7. I/We believe that the person*(s)* named over the page *(and on any extra copies of this form)* is/are the inventor*(s)* of the invention which the above patent application relates to.

Signature [signature] Date 17.6.03

8. Name and daytime telephone number of person to contact in the United Kingdom
JAMES WHITE 01635 871466

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Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

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Patents ADP number *(if you know it)*: 8654642001

DAVID EDWARD COOPER
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LANE, NEWBURY
BERKSHIRE RG14 6PP

Patents ADP number *(if you know it)*: 8042541002

Patents ADP number *(if you know it)*:

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18 JUN 2003

1. Your reference — 1803

2. Patent application number *(The Patent Office will fill in this part)* — 0314093.6

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   MATSUSHITA ELECTRIC INDUSTRIAL Co. LTD.
   1006 OAZA KADOMA, KADOMA-SHI
   OSAKA 571-8501 JAPAN

   Patents ADP number *(if you know it)*

   If the applicant is a corporate body, give the country/state of its incorporation — JAPANESE COMPANY — 591842002

4. Title of the invention

   EXTENDED DYNAMIC RESOURCE ALLOCATION IN PACKET DATA TRANSFER

5. Name of your agent *(if you have one)* —

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   JAMES WHITE
   PANASONIC MOBILE COMMUNICATIONS OF EUROPE LTD.
   2 GABLES WAY, COLTHROP, THATCHAM
   BERKSHIRE RG19 4ZB

   Patents ADP number *(if you know it)* — 8648453001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

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Number of earlier application	Date of filing *(day / month / year)*

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   a) any applicant named in part 3 is not an inventor, or
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Continuation sheets of this form	
Description	11
Claim *(s)*	2
Abstract	1
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Extended dynamic resource allocation in packet data transfer

This invention relates to multiple access communication systems and in particular it relates to dynamic resource allocation in time division multiple access systems.

In Multiple access wireless systems such as GSM, a number of mobile stations communicate with a network. The allocation of physical communication channels for use by the mobile stations is fixed. A description of the GSM system may be found in The GSM System for Mobile Communications by M. Mouly and M. B. Pautet, published 1992 with the ISBN reference 2-9507190-0-7.

With the advent of packet data communications over Time Division Multiple Access (TDMA) systems, more flexibility is required in the allocation of resources and in particular in the use of physical communication channels. For packet data transmissions in General Packet Radio Systems (GPRS) a number of Packet Data CHannels (PDCH) provide the physical communication links. The time division is by frames of 4.615 ms duration and each frame has eight consecutive 0.577 ms slots. A description of the GPRS system may be found in (3GPP TS 43.064 v5.1.1). The slots may be used for uplink or downlink communication. Uplink communication is a transmission from the mobile station for reception by the network to which it is attached. Reception by the mobile station of a transmission from the network is described as downlink.

In order to utilise most effectively the available bandwidth, access to channels can be allocated in response to changes in channel conditions, traffic loading, Quality of Service and subscription class. Owing to the continually changing channel conditions and traffic loadings a method for dynamic allocation of the available channels is available.

The amounts of time that the mobile station receives downlink or transmits uplink may be varied and slots allocated accordingly. The sequences of slots allocated for reception and transmission, the so-called multislot pattern is usually described in the form **RXTY**. The allocated receive (R) slots being the number X and the allocated transmit slots (T) the number Y. A number of multislot classes, one through to 45, is defined for GPRS operation and the maximum uplink (Tx) and downlink (Rx) slot allocations are specified for each class.

In a GPRS system, access to a shared channel is controlled by means of an Uplink Status Flag (USF) transmitted on the downlink to each communicating mobile station (MS). In GPRS two allocation methods are defined, which differ in the convention about which uplink slots are made available on receipt of a USF. The present invention relates to a particular allocation method, in which an equal number "*N*" of PDCH's, a "PDCH" representing a pair of uplink and downlink slots corresponding to each other on a 1-1 basis, are allocated for potential use by the MS. The uplink slots available for actual use by a particular mobile station sharing the uplink channel are indicated in the USF. The USF is a data item capable of taking 8 values V0- V7, and allows uplink resources to be allocated amongst up to 8 mobiles where each mobile recognises one of these 8

values as 'valid', i.e. conferring exclusive use of resources to that mobile. A particular mobile station may recognise a different USF value on each of the slots assigned to that mobile station. In the case of the extended dynamic allocation method, for example, reception of a valid USF in the slot 2 of the present frame will indicate the actual availability for transmission of transmit slots 2…*N* in the next TDMA frame or group of frames, where *N* is the number of allocated PDCHs. Generally for a valid USF received at receiver slot n, transmission takes place in the next transmit frame at transmit slots n, n+1 et seq. to the allocated number of slots (*N*). For the extended dynamic allocation method as presently defined these allocated slots are always consecutive.

The mobile station is not able instantly to switch from a receive condition to a transmit condition or vice versa and the time allocated to these reconfigurations is known as turnaround time. It is also necessary for the mobile station, whilst in packet transfer mode, to perform neighbourhood cell measurements. The mobile station has continuously to monitor all Broadcast Control Channel (BCCH) carriers as indicated by the BA(GPRS) list and the BCCH carrier of the serving cell. A received signal level measurement sample is taken in every TDMA frame, on at least one of the BCCH carriers. (3GPP TS 45.008v5 10.0). The turnaround and measurement times guaranteed by the network for a mobile station depend on the multislot class to which the mobile claims conformance (3GPP TS 45.002v5.9.0 Annex B).

The neighbour cell measurements are taken prior to re-configuration from reception to transmission or prior to re-configuration from transmission to reception.

A mobile station operating in extended dynamic allocation mode presently must begin uplink transmission in the Tx timeslot corresponding to the Rx timeslot in which the first valid USF is recognised. That is to say that there is a fixed relationship in the timing of the downlink allocation signalling and subsequent uplink transmission. Owing to the physical limitations of single transceiver mobile stations some desirable multislot configurations are not available for use.

These restrictions reduce the availability of slots for uplink transmissions thereby reducing the flow of data and the flexibility of response to changing conditions. There is a need therefore to provide a method with which to enable the use of those multislot configurations currently unavailable for Extended Dynamic Allocation.

It is an object of this invention to reduce the restrictions affecting extended dynamic allocation with minimal effect on the existing prescript. This may be achieved by altering the fixed relationship in the timing of the downlink allocation signalling and subsequent uplink transmission for certain classes of mobile station.

In accordance with the invention there is a method for controlling uplink packet data transmissions and a mobile station operating in accordance with the method as set out in the attached claims.

An embodiment of the invention will now be described with reference to the accompanying figures in which:

Figure 1 Illustrates the GPRS TDMA frame structure showing the numbering convention used for uplink (UL) and downlink (DL) timeslots,

Figure 2 Illustrates a prior art 4 slot steady state allocation R1T4

Figure 3 illustrates a 5 slot steady state allocation R1T5 prohibited in the prior art,

Figure 4 illustrates a 5 slot steady state allocation R1T5 enabled by the method of the present invention,

Figure 5 illustrates a shifted USF applied to a class 7 MS with 3 uplink slots allocated,

Figure 6 illustrates a class 7 MS with 2 uplink slots allocated,

Figure 7 is a flow diagram for the implementation of shifted USF in a mobile station

Figure 8 illustrates a transition from one uplink slot to five uplink slots for a class 34 MS,

Figure 9 illustrates a transition from four to five uplink slots for a class 34 MS,

In this embodiment, the invention is applied to a GPRS wireless network operating in accordance with the standards applicable to multislot classes. In figure 1 the GPRS TDMA frame structure is illustrated and shows the numbering convention used for uplink (Tx) and downlink (Rx) timeslots. It should be noted that in practice Tx may be advanced relative to Rx due to timing advance (TA), although this is not shown in the illustration. Thus in practice the amount of time between the first Rx and first Tx of a frame may be reduced a fraction of a slot from the illustrated value of 3 slots due to timing advance.

Two successive TDMA frames are illustrated with downlink (DL) and uplink (UL) slots identified separately. The slot positions within the first frame are shown by the numerals 0 through to 7 with the transmission and reception slots offset by a margin of three slots. This is in accordance with the convention that that the first transmit frame in a TDMA lags the first receive frame by an offset of 3 (thus ordinary single slot GSM can be regarded as a particular case in which only slot 1 of transmit and receive is used)

The remaining figures conform to the illustration of figure 1 but the slot numbering has been removed for extra clarity. The shaded slots are those allocated for the particular states and the arrowed inserts indicate the applicable measurement and turnaround intervals. The hashed slots indicate reception of a valid USF and the timeslot in which that USF is received. As mentioned above, constraints are imposed by the need to allow measurement and turnaround slots and the prescript for these in 3GPP TS 45.002 Annex B limits dynamic allocation as shown in table 1.

Table 1

Multislot class	Maximum number of slots			Minimum number of slots			
	Rx	Tx	Sum	T_{ta}	T_{tb}	T_{ra}	T_{rb}
7	3	3	4	3	1	3	1
34	5	5	6	2	1	1	1
39	5	5	6	2	1	1+to	1
45	6	6	7	1	1	1	to

$\mathbf{T_{ta}}$ is the time needed for the MS to perform adjacent cell signal level measurement and get ready to transmit.

$\mathbf{T_{tb}}$ is the time needed for the MS to get ready to transmit

$\mathbf{T_{ra}}$ is the time needed for the MS to perform adjacent cell signal level measurement and get ready to receive.

$\mathbf{T_{rb}}$ is the time needed for the MS to get ready to receive

It should be noted that in practice the times T_{ta} and T_{tb} may be reduced by a fraction of a slot due to timing advance.

$\mathbf{t_0}$ is 31 symbol periods timing advance offset

With reference to figure 2, a steady state single downlink and 4 uplink slot allocation for a class 34 mobile station is illustrated. The turnaround and measurement periods for this class are shown in table 1 as Tra, Trb and Ttb each having one slot and Tta having two slots. These periods can be accommodated for this allocation when a valid USF is received in time slot 0.

When the allocation of uplink slots extends to five, however, a constraint arises as indicated in the illustration of figure 3 which is for a class 34 mobile station with an allocation of one downlink and five uplink slots.

The constraint occurs at the position indicated by '**A**' because no time is allowed for the changeover from transmit to receive (Trb). In the downlink time slot 0 a valid USF is received and the following two slots provide for Tta. In accordance with the invention, for this embodiment the mobile has uplink slots assigned in the usual way, through the use of **USF_TN0...USF_TN7** Information Elements in Packet Uplink Assignment and Packet Timeslot Reconfigure messages. The network sends the USF, however, for both first and second assigned timeslots on the downlink PDCH associated with the second assigned timeslot.
Considering by way of example a class 34 MS with an assignment of 5 uplink slots (TN0 – TN4) as discussed above where the network sends **USF_TN0** on timeslot 1 rather than timeslot 0. This arrangement is illustrated in figure 4 where it can be seen that slots marked '**B**' and '**C**' provide for turnaround times Tra and Trb respectively.

An allocation by the network of 4 uplink slots to the MS will be signalled by the sending of **USF_TN1** on timeslot 1. The characters of the two signals **USF_TN0** and **USF_TN1** must differ and must be distinguishable by the mobile station.

It is not necessary to add extra information elements to indicate when the Shifted USF mechanism is to be used, as it may be made implicit in the timeslot allocations for the particular multislot class of the mobile station. Therefore no increase in signalling overhead would be required.
With reference to figure 5, another example of an allocation enabled by implementation of a shifted USF is illustrated in figure 5. The application is a class 7 MS with three uplink slots allocated. The USF on downlink slot

1 allocating the 3 uplink slots indicates that the first uplink slot available is uplink slot 0 rather than the usual slot 1. This provides for the Ttb and Tra periods (as required by table 1) and as indicated in figure 5 at D and E respectively. The allocation would not previously have been available for want of a sufficient period for Tra.

The 2 slot allocation illustrated in figure 6 reverts to normal operation i.e. the USF is not shifted. There are no physical constraints in normal allocations for this 2 slot arrangement of figure 6 and the standard USF in time slot 1 allocates uplink slots beginning with uplink slot number 1

Alternatively it may be convenient to apply positive signalling of the shift in position of the uplink allocation and an implementation of a shifted USF in a mobile station operating extended dynamic allocation is illustrated in figure 7. It should be noted that the indication (2) in figure 7 may be explicit (i.e. extra signalling) or implicit (automatic for particular multislot class configuration). With reference to figure 7, the mobile station receives at **1** an assignment of uplink resources and USF's from the network. If at **2**, an indication to use a shifted USF is detected then, for the first USF, the second downlink slot is monitored **(3)** otherwise the first downlink slot is monitored **(4)**. In either case, when a valid USF has been received at **5** then uplink transmissions are initiated in the first uplink slot from the mobile station **(6)**. When no valid USF has been received at **5** then the second downlink slot is monitored for a second USF at **7** and if valid **(8)** then uplink transmissions are initiated in the second uplink slot **(9)**.

In the examples illustrated in figures 2 to 6 the allocations are steady state such that the allocations shown are maintained from frame to frame. The invention is not restricted to steady state allocations and may be applied also to control of uplink resources that change from one frame to another.

Examples of transitions are illustrated in figures 8 and 9. These figures each represent four consecutive frames but have been split for presentation. Figure 8 illustrates the transition from one uplink slot allocation to five uplink slots allocation, for a Class 34 mobile. The first (top) two frames show steady state operation with one slot and the next (bottom) two frames show the transitional frames. For this transition the slot location of the USF is changed.

Figure 9 illustrates the transition from four uplink slots to five uplink slots, for a Class 34 mobile. The first two frames show steady state operation with four slots and the next two frames show the transitional frames. For this transition the USF slot location is constant but the value of the USF is changed.

In order to implement the invention in GPRS for example a table (Table 2) may be constructed for a Type 1 MS to allow extended dynamic allocation using the principles below:

In the case of extended dynamic allocation it is desirable for the MS to be able to "transmit up to its physical slot limit"; specifically, the MS should be able to transmit the maximum number of slots possible according to the limitation of its multislot class, while continuing to receive and decode the

USF value on exactly one slot and performing measurements. If it is not possible to define a multislot configuration which permits the MS to "transmit up to its physical slot limit" using T_{ra}, but it would be possible by using T_{ta}, then T_{ta} shall be used.

If it is not possible to define a multislot configuration for extended dynamic allocation which permits the MS to "transmit up to its physical slot limit" but it would be possible by using the shifted USF mechanism, then shifted USF shall be used. In this case T_{ra} will be used as first preference, but if this is not possible T_{ta} will be used as second preference.

Table 2

Medium access mode	No of Slots	T_{ra} shall apply	T_{ta} shall apply	Applicable Multislot classes	Note
Uplink, Ext. Dynamic	1-3	Yes	-	1-12, 19-45	
	4	No	Yes	33-34, 38-39, 43-45	2
	5	**Yes**	-	**34, 39**	**5**
	5	No	Yes	44-45	2,4
	6	**No**	**Yes**	**45**	**5**
Down + up, Ext. Dynamic	d+u = 2-4	Yes	-	1-12, 19-45	
	d+u = 5, d > 1	Yes	-	8-12, 19-45	
	d = 1, u = 4	No	Yes	30-45	2
	d+u = 6, d>1	Yes		30-45	2,3
	d = 1, u = 5	**Yes**		**34,39**	**5**
	d+u = 7, d>1	No	Yes	40-45	2,4
	d = 1, u = 6	**No**	**Yes**	**45**	**5**
Note 1 Normal measurements are not possible (see 3GPP TS 45.008).					
Note 2 Normal BSIC decoding is not possible (see 3GPP TS 45.008).					
Note 3 TA offset required for multislot classes 35-39.					
Note 4 TA offset required for multislot classes 40-45.					
Note 5 Shifted USF operation shall apply (see 3GPP TS 44.060)					

Claims

1 A method for controlling packet data transmissions in a TDMA communications system wherein transmitters and receivers share channel resources dynamically for uplink and downlink operating periods and where downlink signals control subsequent uplink resource allocations in a fixed timing relationship; characterised by assignment of alternative timing relationships to increase the availability of uplink resources when uplink resources are otherwise constrained by prescribed allocations of measurement and turnaround periods.

2. A method as in claim 1 where the time division for access is by consecutive frames of eight slots

3. A method as in claim 1 or claim 2 where the assignment of an alternative timing relationship is by means of an alternative slot location for the controlling downlink signal.

4. A method as in claim 3 where the controlling downlink signal is delayed by one slot and the alternative timing relationship is a one slot reduction from the fixed timing relationship.

5. A method as in any preceding claim in which the communications system is a General Packet Radio System

6. A method as in any preceding claim where the alternative timing relationships are applied automatically when the controlling downlink signal is received in an alternative slot location.

7. A method as in any preceding claim where the controlling downlink signal is a USF

8. A method as in claims 1 to 5 where the alternative timing relationships are applied in response to a specific downlink signal.

9. A method as in claims 5 to 8 in which the multislot class of operation is class 7, 34, 39 or 45.

10. A method as in claims 5 to 9 in which slots are allocated for the measurement Tra as default where the MS can transmit to its physical transmitter slot limit using Tra otherwise slots are allocated for the measurement Tta.

11. A mobile station operating in accordance with the method of claim 3 in which the response to receipt of a controlling downlink signal in an alternative slot location is automatically to apply an alternative timing relationship.

12. A mobile station operating in accordance with the method of claim 8 in which alternative timing relationships are applied in response to a specific downlink signal.

ABSTRACT

Extended dynamic resource allocation in packet data transfer

A method for control of packet data transmissions in a TDMA wireless network to provide for additional choices in the allocation of communication channels. The fixed relationship in the timing of the downlink allocation signalling and subsequent uplink transmission is altered for certain classes of mobile station to avoid physical constraints. Examples of variations in USF signalling in GPRS are given.

(Figs 1-3)

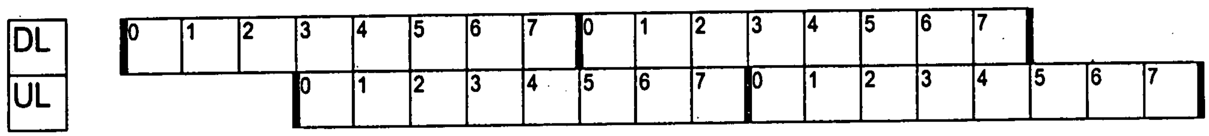


Figure 1

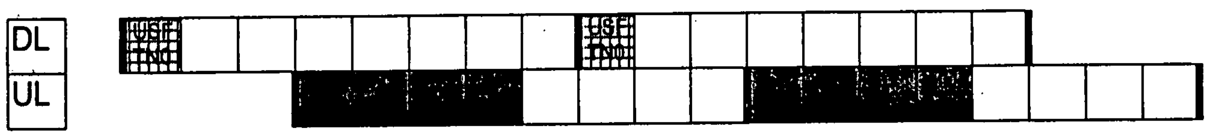


Figure 2

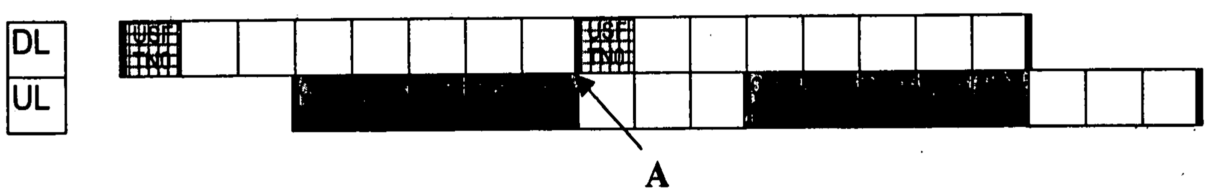


Figure 3

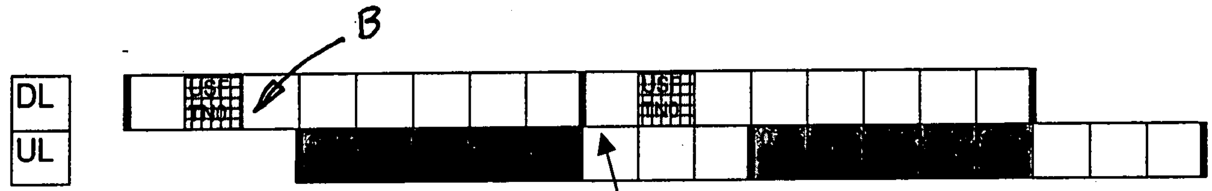


Figure 4

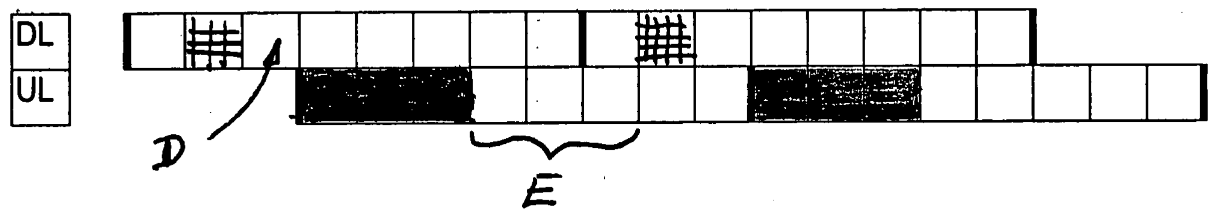


Figure 5

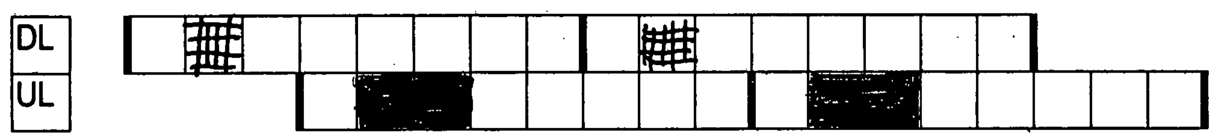
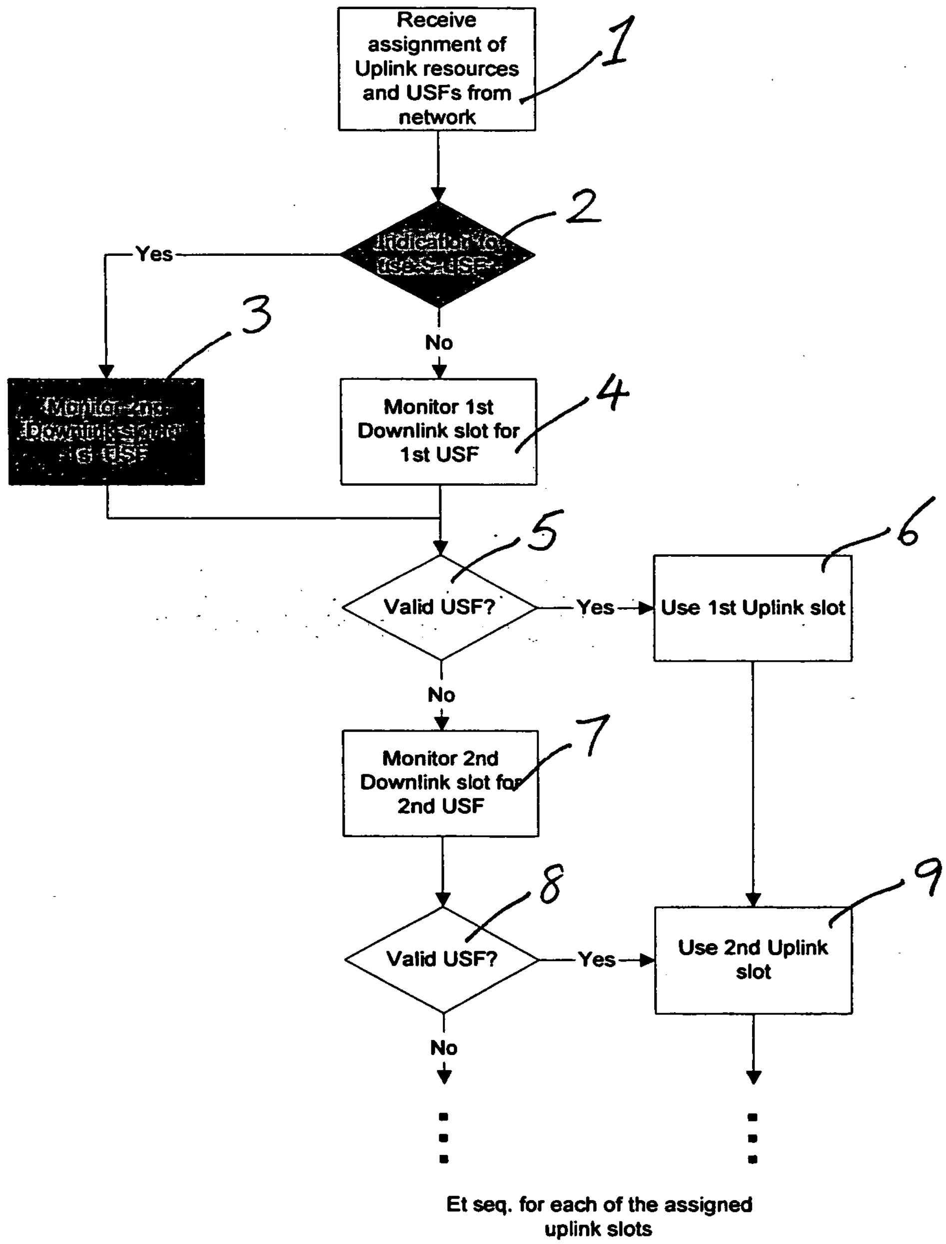


Figure 6



Receive assignment of Uplink resources and USFs from network
1
[redacted]
2
Yes
No
[redacted]
3
Monitor 1st Downlink slot for 1st USF
4
Valid USF?
5
Yes
Use 1st Uplink slot
6
No
Monitor 2nd Downlink slot for 2nd USF
7
Valid USF?
8
Yes
Use 2nd Uplink slot
9
No
Et seq. for each of the assigned uplink slots

FIGURE 7

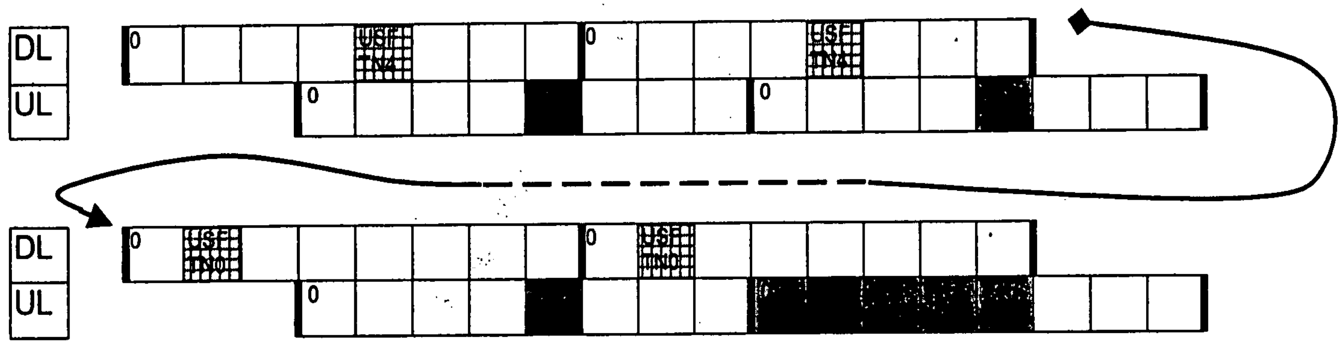


Figure 8

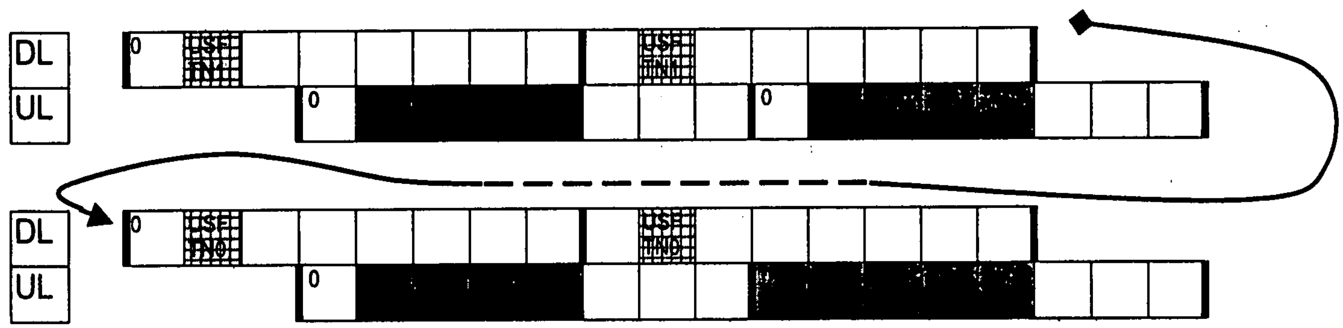


Figure 9